Effect of Spiral Split Ring Resonator (S-SRR) structure on Truncated Pyramidal Microwave Absorber Design

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1. Introduction

This paper discusses on the effect of the spiral split ring resonator on the truncated pyramidal microwave absorber. Split ring resonator (SRR) structure can potentially be incorporated onto the truncated pyramidal microwave absorber to increase the reflection loss performance. There are many ways to increase the pyramidal microwave absorber performance. The ways are focusing the new hybrid shapes, using high carbon material, and adding the left handed material structure on the pyramid microwave absorber. Left handed material or metamaterial is an artificial material that does not exist in the real nature like FR4, Taconic, Rogers or RT Duriod.

There are many types of left handed material that had been used by several researchers such as split ring resonator (SRR), and photonic band gap (PBG), electromagnetic band gap (EBG) and artificial magnetic conductor (AMC). In this research, spiral split ring resonator (S-SRR) is used to increase the microwave absorber performance. It has the potential to increase the reflection loss or S_{11} results of the microwave absorber at the several frequencies.

2. Unit Cell of Spiral SRR

There are many different types of split ring resonator structures. The most used and first design is edge couple SRR (EC-SRR) by Pendry [1] and Smith [2]. The other designs are open SRR (O-SRR), and broadside couple (BC-SRR). In microwave range application, this structure can be implementing in antennas, microwave absorbers, filters and oscillators and others.

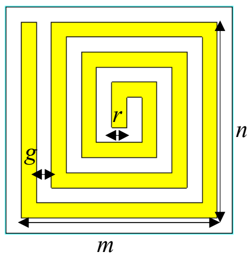
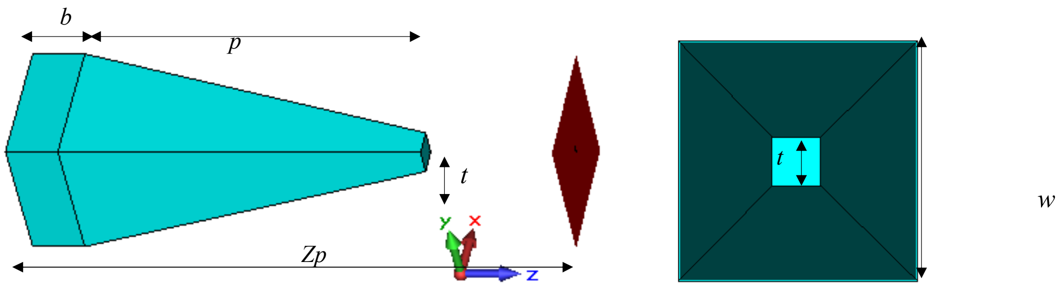


Figure 1: Schematic diagram for single unit of spiral split ring resonator. Dimension: *m* and *n* = 2.6 mm, *r* = 0.2 mm, *g* = 0.2 mm, thickness of copper = 0.035 mm, FR4 substrate thickness = 1.6 mm.

Figure 1 shows the plan view of the spiral split ring resonator S-SRR design. It consists of one spiral ring wire of 2.6 mm x 2.6 mm x 0.035 mm dimension on the FR4 substrate. The ground of substrate is consisting copper with 3 mm x 3 mm x 0.035 mm dimension.

3. Pyramidal Microwave Absorber Design

The commercial microwave like TDK ICT-030 and VHP-NRL absorbers are designed to be made of plastic foamed-based materials like polystyrene or polyurethane with impregnating carbon as its mixed material. In this design, rice husk with dielectric constant, $\varepsilon_r = 2.9$ had been used as the based material of pyramidal microwave absorber.



(a) (b)

Figure 2: Schematic diagram of truncated pyramidal microwave absorber. (a) Side view; (b) plan view. Dimension: b = 2 cm, p = 13 cm, t = 1 cm, w = 5 cm, Zp = 30 cm.

Figure 2 shows the schematic diagram of truncated pyramidal microwave absorber. The dimension of the absorber is 5 cm width x 5 cm length x 13 cm height. This of the pyramidal microwave absorbers design has been performed by Nornikman et al. [3-5]

4. Absorber with Spiral SRR

There are many parameters that affect the return loss performance of the SRR absorber such as the dimension of S-SRR, N-number of SRR, split ring gap, thickness of the substrate used and others. Figure 3 shows the N-number of S-SRR on the truncated pyramidal microwave absorber while Figure 4 shows the different location of the S-RR on truncated pyramidal microwave absorber.

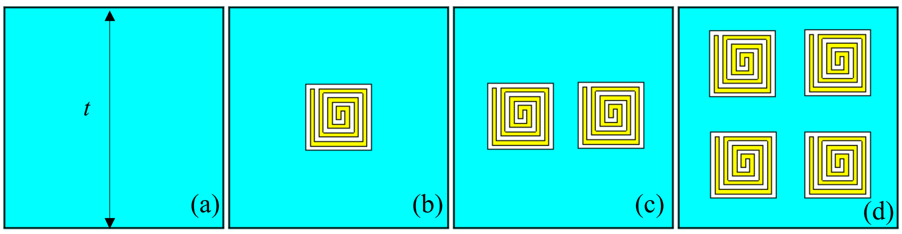


Figure 3: N-number of Spiral SRR on truncated pyramidal microwave absorber. (a) No S-SRR; (b) single S-SRR; (c) double S-SRR; (d) array S-SRR. The dimension of the truncated part, t = 1 cm.

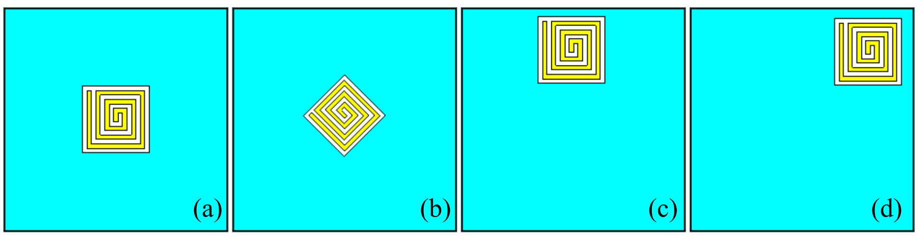


Figure 4: Different location of Spiral SRR on truncated pyramidal microwave absorber. (a) location A; (b) location A (with 45^0 rotation); (c)location B; (d) location C

5. Result

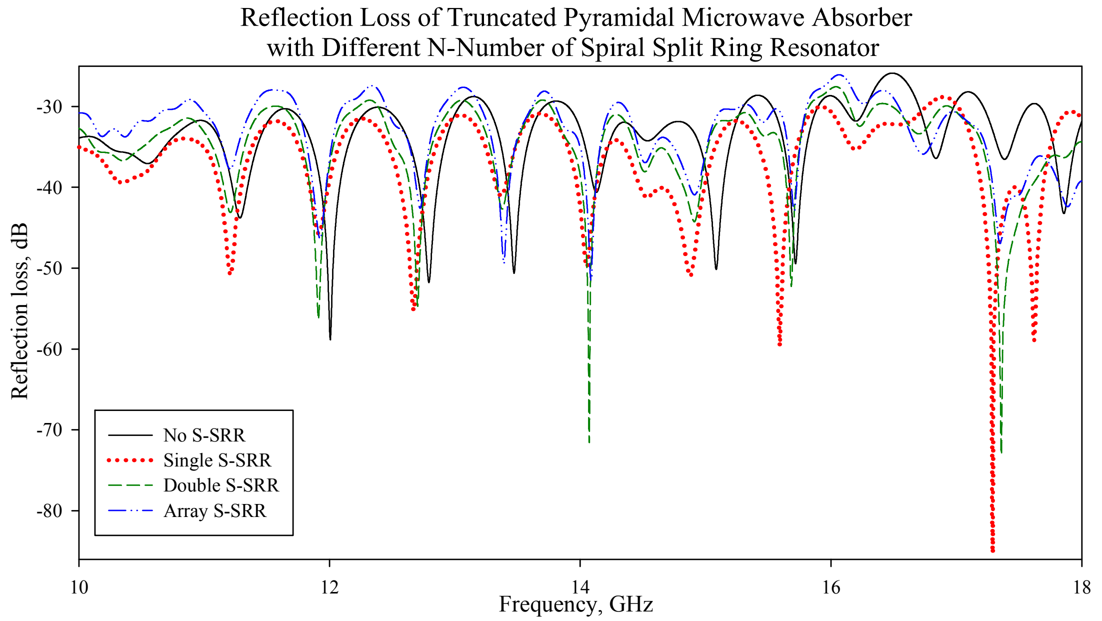


Figure 5: Reflection loss of truncated pyramidal microwave absorber with different N-number of spiral SRR structure

Table 1: Reflection loss of truncated pyramidal microwave absorber with different N-number of spiral SRR structure

Frequency range (GHz)	Average reflection loss with different N-number of S-SRR (dB)			
	No S-SRR	Single S-SRR	Double S-SRR	Array S-SRR
10-12	- 35.025	- 37.138	- 35.070	- 32.293
12-14	- 34.426	- 35.437	- 33.714	- 32.057
14-16	- 34.323	- 38.288	- 35.358	- 33.507
16-18	- 31.384	- 35.710	- 34.970	- 34.231
10-18	- 33.772	- 36.641	- 34.779	- 33.023

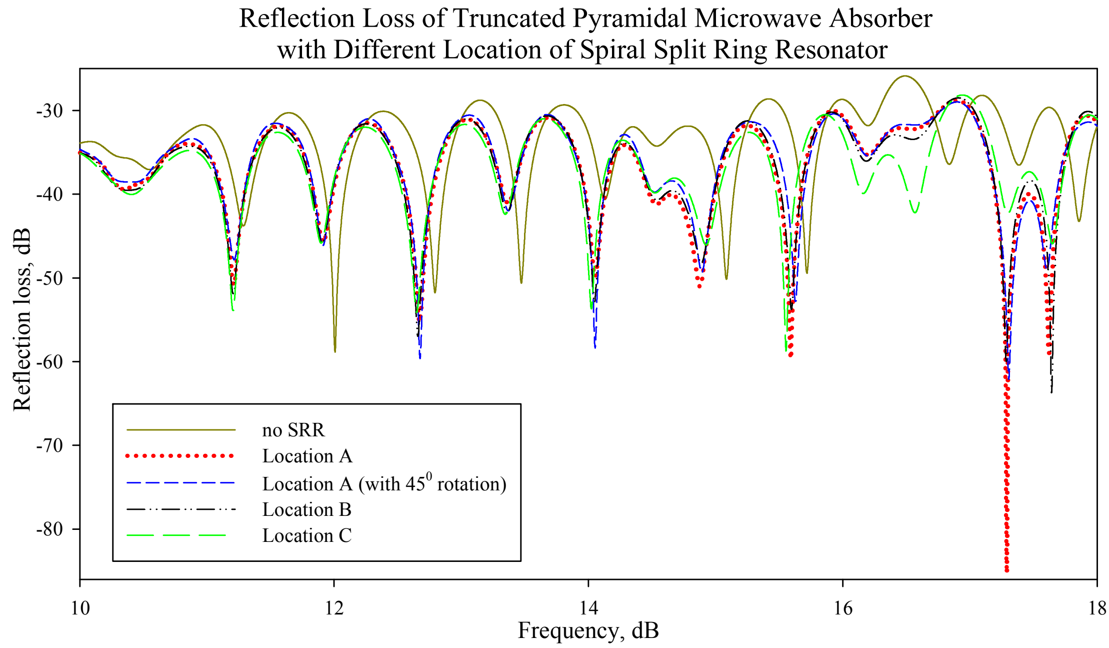


Figure 6: Reflection loss of truncated pyramidal microwave absorber with different location of spiral SRR structure

Table 2: Reflection loss of truncated pyramidal microwave absorber with different location of spiral SRR structure

Frequency range (GHz)	Average reflection loss with different location of S-SRR (dB)				
	No S-SRR	Location A (0^0 rotation)	Location A (45^0 rotation)	Location B	Location C
10-12	- 35.025	- 37.138	- 36.704	- 37.465	- 37.936
12-14	- 34.426	- 35.437	- 35.261	- 35.529	- 35.997
14-16	- 34.323	- 38.288	- 37.404	- 37.834	- 37.699
16-18	- 31.384	- 35.710	- 35.527	- 35.535	- 35.764
10-18	- 33.772	- 36.641	- 36.220	- 36.587	- 36.840

Figure 5 and Table 1 shows reflection loss performance results of the truncated pyramidal microwave absorber with different N-number of S-SRR structure. The frequency ranges from 10 GHz to 18 GHz. The best point had been shown at 17.288 GHz by single S-SRR absorber with – 85.264 dB of reflection loss. From the graph, the single S-SRR also achieves the best average reflection loss at all frequency range. It increase 8.49 % return loss performance compare to the normal truncated absorber without S-SRR structure.

Figure 6 and Table 2 represent effect of the S-SRR location on the truncated pyramidal microwave absorber. From the analysis, different S-SRR locations also effect the return loss performance but only in small percentages. The S-SRR that located at the edge of the truncated part gives the highest impact to the microwave absorber with 9.09 % return loss performance compare to the normal truncated absorber without S-SRR structure. It achieves - 36.840 dB compare to the normal truncated absorber with only – 33.772 dB.

6. Conclusion

The spiral split ring resonator (S-SRR) design incorporated into the truncated pyramidal microwave absorber has been presented in this paper. The incorporation of the S-SRR increases the reflection loss performance of the truncated pyramidal microwave absorber.

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